CLAIMS

What is claimed is:

1. A skin-texture sensor for sensing a skin texture having a plurality of ridges and a plurality of valleys, comprising:

a) a base;

b) a plurality of conductive row lines disposed on the base;

c) a plurality of conductive column lines disposed on the base and insulated from the row lines; and

d) an array of membrane switches disposed on the base such that a spacing between adjacent switches in the array is less than one half of a spacing between adjacent ridges, each membrane switch corresponding to a pair of one of the row lines and one of the column lines, said each membrane switch comprising:

a lower electrode disposed on the base and electrically connected to said one of the row lines, and

a flexible upper membrane structure disposed over and spaced apart from the lower electrode when in a quiescent state, the membrane structure comprising an upper electrode disposed facing the lower electrode and connected to said one of the column lines, wherein

applying a ridge of the texture to said each membrane switch causes a flexure of the membrane resulting in a contact between the lower electrode and the upper electrode, the contact establishing an electrical communication between said one of the row

lines and said one of the column lines, and wherein

disposing a valley of the texture over said each membrane switch does not result in the contact between the lower electrode and the upper electrode.

2. The sensor of claim 1 wherein the upper electrode comprises a conductive membrane anchored to the base around an edge of the conductive membrane.

3. The sensor of claim 2, wherein the membrane structure further comprises an insulative diaphragm stacked over the upper electrode and anchored to the base around an edge of the insulative diaphragm.

4. The sensor of claim 3, wherein a height of a top surface of the insulative diaphragm is within 4 μm of a top height of a support surface of the sensor, the support surface being outside of any membrane structure of the array.

5. The sensor of claim 4, wherein the height of the top surface is within 0.5 μm of the top height of the support surface.

6. The sensor of claim 3, wherein the insulative diaphragm is formed by a polymer layer.

7. The sensor of claim 1, wherein the upper electrode comprises a conductive membrane having an annular crease.

8. The sensor of claim 1, wherein the upper electrode comprises a conductive membrane having at least two concentric annular creases.

9. The sensor of claim 1, wherein said each membrane switch defines a closed chamber defined generally between the lower electrode and the membrane structure, the chamber being closed to external particles so as to protect the lower electrode and the upper electrode from contamination.

10. The sensor of claim 9, wherein the closed chamber is open to a passage of air from an external environment of the sensor, for allowing an equalization of pressure between the external environment and the closed chamber.

11. The sensor of claim 9, wherein said each membrane switch includes a set of sealed vents extending between the chamber and an exterior of the chamber, wherein the set of vents in an unsealed state provide access to the chamber for removing a sacrificial material from the chamber during a manufacture of the sensor.

12. The sensor of claim 9, further comprising a set of interswitch tunnels establishing fluidic communication between a plurality of closed chambers of adjacent switches, for allowing an equalization of pressure between the plurality of closed chambers.

13. The sensor of claim 1, further comprising a flexible insulative sheet disposed over the array of membrane

switches, for coupling the texture to the membrane switches.

14. The sensor of claim 1, further comprising a passive resistor connected in series between said each membrane switch and a line selected from the pair of said one of the row lines and said one of the column lines.

15. The sensor of claim 14, further comprising a pull-down passive resistor connecting a line selected from each of the row lines and each of the column lines to a lower electrical potential, for improving a discrimination of the sensor between an open state and a closed state of said each membrane switch.

16. The sensor of claim 1, further comprising an active device connecting said each membrane switch and a line selected from the pair of said one of the row lines and said one of the column lines.

17. The sensor of claim 16, further comprising an active device connecting a line selected from each of the row lines and each of the column lines to a lower electrical potential.

18. The sensor of claim 1, wherein the base comprises a semiconductor substrate.

19. The sensor of claim 18, wherein the base further comprises an insulator layer disposed over the semiconductor substrate.

20. The sensor of claim 1, wherein the base comprises an insulating substrate.

21. The sensor of claim 1, wherein the base comprises a glass substrate.

22. The sensor of claim 1, wherein the skin texture is a fingerprint texture, and said sensor is sized to sense a fingerprint.

23. A skin-texture sensor for sensing a skin texture having a plurality of ridges and a plurality of valleys, the sensor comprising:

an array of membrane switches disposed on a base such that a spacing between adjacent switches in the array is less than one half of a spacing between adjacent ridges, each membrane switch comprising:

a) a lower electrode disposed on the base; and

b) a flexible upper membrane structure disposed over the lower electrode and comprising an upper electrode disposed facing the lower electrode, wherein applying a ridge of the texture to said each membrane switch causes a flexure of the membrane resulting in a contact between the lower electrode and the upper electrode, and wherein disposing a valley of the texture over said each membrane switch does not result in the contact between the lower electrode and the upper electrode.

24. The sensor of claim 23 wherein the upper electrode comprises a conductive membrane anchored to the base around an edge of the conductive membrane.

25. The sensor of claim 24, wherein the membrane structure further comprising an insulative diaphragm stacked over the upper electrode and anchored to the base around an edge of the insulative diaphragm.

26. The sensor of claim 23, wherein the upper electrode comprises a conductive membrane having an annular crease.

27. The sensor of claim 23, wherein said each membrane switch defines a closed chamber defined generally between the lower electrode and the membrane structure, the chamber being substantially closed to external particles so as to protect the lower electrode and the upper electrode from contamination.

28. The sensor of claim 27, wherein the closed chamber is open to a passage of air from an external environment of the sensor, for allowing an equalization of pressure between the external environment and the closed chamber.

29. The sensor of claim 27, further comprising a set of interswitch tunnels establishing fluidic communication between a plurality of closed chambers of adjacent switches, for allowing an equalization of pressure between the plurality of closed chambers.

30. A texture sensor for sensing a texture having a plurality of protrusions and a plurality of valleys, the sensor comprising:

an array of membrane switches disposed on a base, each membrane switch comprising:

a) a lower electrode disposed on the base; and

b) a flexible upper membrane structure disposed over the lower electrode and spaced apart from the lower electrode when in a quiescent state, the upper membrane structure comprising an upper electrode disposed facing the lower electrode, wherein disposing a protrusion of the texture over said each membrane switch causes a flexure of the membrane resulting in a contact between the lower electrode and the upper electrode, and wherein disposing a valley of the texture over said each membrane switch does not result in the contact between the lower electrode and the upper electrode.

31. The sensor of claim 30 wherein the upper electrode comprises a conductive membrane anchored to the base around an edge of the conductive membrane.

32. The sensor of claim 31, wherein the membrane structure further comprising an insulative diaphragm stacked over the upper electrode and anchored to the base around an edge of the insulative diaphragm.

33. The sensor of claim 30, wherein the upper electrode comprises a conductive membrane having an annular crease.

34. The sensor of claim 30, wherein said each membrane switch defines a closed chamber defined generally between the lower electrode and the membrane structure, the chamber being substantially closed to external particles so as to protect the lower electrode and the upper electrode from contamination.

35. The sensor of claim 34, wherein the closed chamber is open to a passage of air from an external environment of the sensor, for allowing an equalization of pressure between the external environment and the closed chamber.

36. The sensor of claim 34, further comprising a set of interswitch tunnels establishing fluidic communication between a plurality of closed chambers of adjacent switches, for allowing an equalization of pressure between the plurality of closed chambers.

37. The sensor of claim 30, wherein the texture is a skin texture, and the array of membrane switches are spaced to sense the skin texture.

38. The sensor of claim 37, wherein an interswitch spacing of the array is less than or equal to 400 microns.

39. The sensor of claim 38, wherein the interswitch spacing is less than or equal to 200 microns.

40. An integrated circuit chip sensor for sensing a texture that has a plurality of ridges and a plurality of valleys, comprising:

a) a substrate;

b) a plurality of row lines;

c) a plurality of column lines; and

d) a plurality of membrane switches disposed on the substrate in an array such that each row line and each column line is connected to a plurality of membrane switches, each switch including:

a lower electrode electrically connected to one of the row lines; and

a flexible membrane comprising an upper electrode spaced apart from said lower electrode when in a quiescent state and electrically connected to one of the column lines; wherein

a ridge of the texture causes flexure of the membrane and thereby results in movement of the upper electrode and a change in a state of electrical contact between the upper electrode and the lower electrode, and wherein

a valley of the texture disposed over another of the switches does not result in flexure of the membrane and the change in state of electrical contact between the upper electrode and the lower electrode associated with said another switch.

41. The sensor of claim 40, wherein the membrane structure further comprises an insulative diaphragm stacked over the upper electrode.

42. The sensor of claim 41, wherein a height of a top surface of the insulative diaphragm is within 4 μm of a top height of a support surface of the sensor, the support surface being outside of any membrane structure of the array.

43. The sensor of claim 40, wherein said each membrane switch defines a closed chamber defined generally between the lower electrode and the membrane structure, the chamber being substantially closed to external particles so as to protect the lower electrode and the upper electrode from contamination.

44. The sensor of claim 43, wherein the closed chamber is open to a passage of air from an external environment of the sensor, for allowing an equalization of pressure between the external environment and the closed chamber.

45. The sensor of claim 43, wherein said each membrane switch includes a set of sealed vents extending between the chamber and an exterior of the chamber, wherein the set of vents in an unsealed state provide access to the chamber for removing a sacrificial material from the chamber during a manufacture of the sensor.

46. The sensor of claim 43, further comprising a set of interswitch tunnels establishing fluidic communication between a plurality of closed chambers of adjacent switches, for allowing an equalization of pressure between the plurality of closed chambers.

47. The sensor of claim 40 wherein the array of membrane switches is disposed on the substrate such that a spacing between adjacent switches in the array is less than one half of a spacing between adjacent ridges.

48. A texture sensor for sensing a texture having a plurality of protrusions and a plurality of valleys, the sensor comprising an array of membrane switches disposed on a base, each membrane switch comprising:

a) a fixed electrode rigidly coupled to the base; and

b) a flexible upper membrane structure disposed over the base such that a cavity separates a central region of

the membrane structure and the base when the fixed electrode and the movable electrode are not in contact, the membrane structure comprising a movable electrode disposed facing the fixed electrode, wherein disposing a protrusion of the texture over said each membrane switch causes a flexure of the membrane resulting in a change in contact state between the fixed electrode and the movable electrode, and wherein disposing a valley of the texture over said each membrane switch does not result in the change in contact state between the fixed electrode and the movable electrode.

49. The sensor of claim 48, wherein the fixed electrode is disposed underneath the movable electrode, and wherein the change in contact state is a change from an open quiescent state to a closed state.

50. The sensor of claim 48, wherein the fixed electrode is disposed above the movable electrode, and wherein the change in contact state is a change from a closed quiescent state to an open state.

51. A method of detecting a texture, comprising:

a) depressing the texture over a sensor comprising an array of membrane switches, each membrane switch comprising a fixed lower electrode and a flexible upper membrane structure including an upper electrode disposed over the lower electrode;

b) identifying a plurality of closed membrane switches, wherein a ridge of the texture disposed over each of the closed switches causes a flexure of a membrane structure of said each of the closed switches and an

electrical contact between a lower electrode and an upper electrode of said each of the closed switches; and

c) identifying a plurality of open membrane switches, wherein a valley of the texture disposed over each of the open switches does not cause an electrical contact between a lower electrode and an upper electrode of said each of the open switches.

52. The method of claim 51, wherein the texture is a skin texture.

53. The method of claim 52, wherein the skin texture is a fingerprint texture.

54. The method of claim 51, further comprising a step of equalizing a plurality of pressures corresponding to a plurality of interconnected closed chambers defined by adjacent membrane switches of the array.

55. The method of claim 51, further comprising a step of determining a quiescent state of said each membrane switch while the texture is not depressed over the sensor.

56. The method of claim 54, wherein identifying the plurality of closed membrane switches comprises identifying a subset of membrane switches having undergone a change in state between a time of determining the quiescent state and a time of depressing the texture over the sensor.

57. A method of making an integrated texture sensor for sensing a texture that is protected from external contaminating particulates and will self-equalize using air from outside the sensor, comprising:

a) forming a plurality of row lines and a plurality of column lines on a substrate, each of the row lines and column lines being insulated from each other, the row lines and column lines intersecting to form a switch area between adjacent row lines and adjacent column lines;

b) forming a lower electrode in each of a plurality of switch areas;

c) forming a sacrificial area directly over the lower electrode and a non-sacrificial area around the sacrificial area;

d) forming a membrane above the sacrificial area, the membrane being anchored to the non-sacrificial area, the membrane comprising an upper electrode disposed directly above the sacrificial area, wherein the membrane does not cover a channel area adjacent to the sacrificial area;

e) removing the sacrificial area by introducing a sacrificial etchant through the channel area, thereby forming a cavity region at each sacrificial area; and

f) sealing the channel so as to close the cavity region from the external contaminating particulates while still self-equalizing pressure using the air that is external to the sensor that can flow through the channel.

58. A method of making a skin-texture sensor for sensing a skin texture having a plurality of ridges and a plurality of valleys, comprising:

a) establishing a base;

b) disposing a plurality of conductive row lines on the base;

c) disposing a plurality of conductive column lines on the base, the column lines being insulated from the row lines; and

d) forming an array of membrane switches on the base such that a spacing between adjacent switches in the array is less than one half of a spacing between adjacent ridges, each membrane switch corresponding to a pair of one of the row lines and one of the column lines, wherein forming the array comprises:

disposing a lower electrode on the base,

electrically connecting the lower electrode to said one of the row lines,

disposing a flexible upper membrane structure over the lower electrode, the membrane structure comprising an upper electrode disposed facing the lower electrode and connected to said one of the column lines, wherein

applying a ridge of the texture to said each membrane switch causes a flexure of the membrane resulting in a contact between the lower electrode and the upper electrode, the contact establishing an electrical communication between said one of the row lines and said one of the column lines, and wherein

disposing a valley of the texture over said each membrane switch does not result in the contact between the lower electrode and the upper electrode.